

## Stature estimation from the length of the distal phalanges prints among Egyptian using regression analysis

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### Abstract

**Introduction:** Identification is critically important in forensic medicine in cases of mass disasters where mutilated and amputated body parts are frequently found. Stature estimation is the main element of identification. Fingerprint anthropometry can provide useful data to estimate stature for identification purposes. The current research aimed to identify the stature from the length of the distal phalanges prints among Egyptians using regression analysis.

**Material and Methods:** The study was conducted on 150 adults in the age group of 18 to 40 years. The cleaned hands were set on an inked plate and measurements of the distance between the most projecting points on the tip of the fingerprints and to the distal digital crease mark were taken.

**Results:** The mean stature was significantly longer in males than in females. The mean length of the distal phalanges prints was higher in the right hand than in the left hand in males, and in the left hand than in the right hand in females. Correlation coefficient (R) values were comparatively higher in males. Also, the coefficient of determination (R<sup>2</sup>) was higher in males and all measurements showed a significant positive correlation with the stature, where  $P < 0.05$ .

**Discussion:** The regression equations of distal phalanges prints measurements could be valuable for the determination of stature among adult Egyptians for forensic purposes.

### Keywords

Forensic; Fingerprints; Stature; Distal phalanges; Egyptians

DOI: 10.4328/ACAM.20488 Received: 2021-01-16 Accepted: 2021-03-15 Published Online: 2021-03-28 Printed: 2021-08-01 Ann Clin Anal Med 2021;12(8):895-899

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## Introduction

Identification is the assessment of the individuality of a living or dead individual. It is the backbone of any forensic examination, regardless of whether it is of the suspect from the actual proof at the crime scene or of the victim. Various kinds of identification are available as criminal, civil, personal, and lawful identification [1]. Thus, the identification of the obscure body is a moral and human duty that lies on the shoulder of the forensic pathologist, anthropologist, dentist, and police [2].

Anthropometry alludes to the measurement of the human individual. It has been utilized for recognizable proof, to understand actual human variety [3,4]. The investigation of forensic and archaeological human remaining parts depends on the assessment of bio-demographic parameters, including stature, age, weight, and gender. Thus, the estimation of human stature is a significant parameter in identification in cases as homicide, theft, housebreakings, and bomb blasting incidents dependent on the physical evidence presented in the crime scene. Human stature could be predicted through the measurements of various body parts that are known as mathematical procedures [5-7]. In the mathematical techniques, stature is assessed from independent variables using equations that depend on the linear relationship between height and the variable [8,9]

Numerous researches have been led on the prediction of stature from different body parts like the trunk, intact vertebral column, upper and lower limbs, foot and footprints, hands, and handprints [10].

Fingerprints are unique characteristics of human beings. Notably, they are highly distinctive among persons [11]. The principal reason that fingerprints are so significant in a forensic setting is that the hands are in usual constant physical contact with surroundings and leave a personal signature behind [12].

The fingerprint makes a significant biometric system used throughout the world. It is valuable physical evidence found in crime scenes [13].

Therefore, the current work aimed to identify the stature from the length of the distal phalanges prints among Egyptians using regression analysis.

## Material and Methods

The present work is a prospective cross-sectional study that was carried out at the Department of Forensic Medicine and Clinical Toxicology, Faculty of Medicine, the University of Alexandria during the academic year 2019- 2020. Ethical approval was obtained from the Ethics Committee of the Faculty of Medicine, Alexandria University (IRB Number: 00012098, FWA Number: 00018699, Approval serial number: 0304539).

Informed consent was obtained from all the individuals before participation in the present study. Persons with any apparent hand-related disease or injury and those with orthopedic deformity were excluded from the research.

Stature was measured using a portable body meter measuring device following the standard procedure; the height of the individual was taken at a fixed time. The height (stature) of the subject was measured in a standing posture with bared head and foot. The person stands barefoot in an erect position with their heels, buttocks, back and the back of their head against

the wall with both feet kept beside and hands presented down on the sides and the measurement was taken from the vertex to the floor in centimeters [14].

The cleaned hands were set on an inked plate with gentle pressure and then impressed on an A4 size white paper. The thumb was in the abducted position and other fingers in the extended position and the distance between the most forwarding projecting points on the tip of the fingerprints Thumb [T], Index [I], Middle [M], Ring [R] and Little [L] to the distal digital crease mark (A) was taken [14].

The landmarks and measurement of the length of the distal phalanges on the right-hand print are illustrated in Figure 1.

I. AT – length, the measurement taken from the most forwarding projecting points on the tip of the thumb fingerprint to the distal digital crease.

II. AI – length, the measurement taken from the anterior point of index fingerprint to the distal digital crease.

III. AM – length, the measurement taken from the anterior point of the middle fingerprint to the distal digital crease.

IV. AR – length, the measurement taken from the anterior point of ring fingerprint to the distal digital crease.

V. AL – length, the measurement taken from the anterior point of the little fingerprint to the distal digital crease.

### Statistical analysis of the data

Information was entered into the computer and analyzed using IBM SPSS software package version 20.0. Student's t-test was evaluated to match two groups for normally distributed quantitative variables. Paired t-test was utilized for correlation between various sides for normally distributed quantitative variables. From the analyses, Pearson's correlation coefficient (R) and standard error of estimate (SEE) were obtained and the coefficient of determination (R<sup>2</sup>) was found to be the most proper one for estimation of stature. The linear regression analysis method was utilized for stature determination from different distal phalanges prints measurements as the estimation of stature from distal phalanges prints length with regression analysis is more reliable and accurate [15]. The level of significance was set at  $p \leq 0.05$

## Results

The study was carried out on 150 adult Egyptian persons (104 males and 46 females) of known and confirmed age (18-40 years).

- In males, the stature ranged from: 165.0 to 196.0 cm (mean 177.0 cm)
- In females, the stature ranged from: 160.0 to 176.0cm (mean 166.8 cm).
- The research demonstrated that the mean stature was significantly higher in males than females ( $p < 0.001$ ). (Table 1)

**Table 1.** Descriptive statistics of stature in males and females of adult Egyptians

Sex	N	Min (cm)	Max (cm)	Mean (cm)	SD
Male	104	165.0	196.0	177.0	7.4
Female	46	160.0	176.0	166.8	5.7
t (p)		8.352*(<0.001*)			

t: Student t-test

\*: Statistically significant at  $p \leq 0.05$

Min: minimum; Max: maximum; SD: standard deviation; N: sample size

• Distal phalanges lengths (cm) in males in both right and left hand:

The mean length of the thumb distal phalanges prints was found to be longer than other distal phalanges prints lengths both in right and left hands in males, followed by the mean length of the ring distal phalanges prints, while the mean length of the little distal phalanges prints was found to be shorter than other distal phalanges prints lengths.

The mean length of the distal phalanges prints was found to be longer in right hands than in left hands, except for the length of the index distal phalanges prints, which was equal in both hands.

There was no significant difference between the mean length of the right and left hands distal phalanges prints, except the length of the little distal phalanges prints, which was significantly higher in right than left hands.

• Distal phalanges lengths in females in both hands:

The distal phalanges prints measurements in females were found to be longer in left hands than in right hands, except for the mean length of the index distal phalanges prints, which was equal in both hands. There was no significant difference between the length of the distal phalanges prints in left and right hands, except for the length of the ring distal phalanges prints and the length of the little distal phalanges prints.

• Distal phalanges lengths in a pooled sample:

The pooled sample showed the combination of male and females distal phalanges measurements in which there was no

significant difference between the length of the distal phalanges prints in both right and left hand. (Table 2)

• Stature estimation through measurement of distal phalanges lengths in adult males and females using linear regression equations:

The different linear regression equations established to estimate stature from various distal phalanges lengths in both hands in both males and females. The correlation between stature and distal phalanges lengths is demonstrated as Karl Pearson's correlation coefficient (R). The R values showed to be higher in males (0.014 - 0.550) than females (0.097 - 0.391). Regarding the coefficient of determination (R<sup>2</sup>), the predictive accuracy showed to be higher in males when compared with females, and all measurements showed a positive correlation with the stature. The established linear regression equations to estimate stature from distal phalanges prints lengths in both males and females illustrated accuracy and reliability, as the values of the standard error of estimation (SEE) showed to be low.

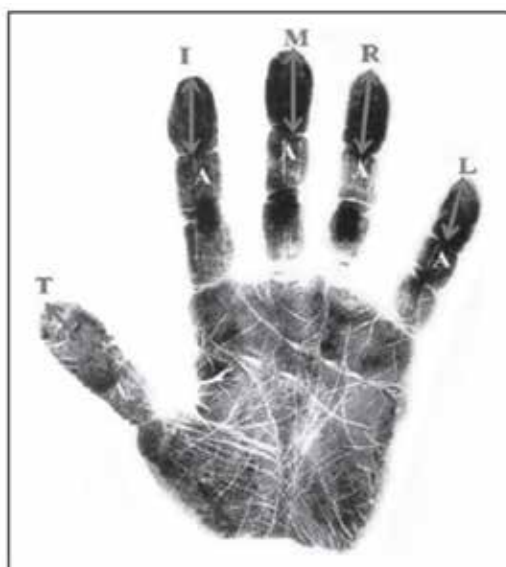
• Stature estimation through measurement of distal phalanges lengths in pooled samples using linear regression equations:

The R values in pooled samples of Egyptians ranged from 0.156 to 0.596, and the standard error of estimation values ranged from 6.718 to 8.264, which showed to be low. In the case of a fingerprint of unknown gender, the regression equations derived for the pooled sample may be used to determine the stature (Table 3).

**Table 2.** Descriptive statistics of distal phalanges prints lengths (cm) in a pooled sample of adult Egyptians (N=150)

Variable	Right Hand				Left Hand				t	p
	Min	Max	Mean	SD	Min	Max	Mean	SD		
T	2.3	3.9	3.15	0.35	2.5	4.0	3.14	0.35	0.253	0.801
I	2.0	3.0	2.48	0.26	2.0	2.9	2.48	0.20	0.146	0.884
M	1.9	3.0	2.57	0.28	2.1	3.0	2.58	0.23	0.706	0.481
R	2.2	3.1	2.57	0.25	2.1	3.0	2.59	0.23	1.122	0.264
L	1.9	2.8	2.37	0.24	1.9	2.9	2.34	0.24	1.476	0.142

t: Paired t-test P-value  
 \*: Statistically significant at p ≤ 0.05  
 Min: minimum; Max: maximum; SD: standard deviation; N: sample size  
 T: Thumb, I: Index, M: Middle, R: Ring and L: Little



**Figure 1.** Landmarks and measurements of distal phalanges prints on the right hand print [14].

**Table 3.** Linear regression equations for stature determination through various distal phalanges print length in a pooled samples of adult Egyptians (N = 150)

Side	Variable	R	R <sup>2</sup>	Regression equation	SEE
Right	T	0.312*	0.097	S=149.584 + 7.767T	7.948
	I	0.156	0.024	S=160.722 + 5.326I	8.264
	M	0.475*	0.225	S=135.854 + 14.968M	7.364
	R	0.596*	0.355	S=117.093 + 22.321R	6.718
	L	0.437*	0.191	S=134.491 + 16.866L	7.526
Left	T	0.195*	0.038	S=159.250 + 4.675T	8.205
	I	0.336*	0.113	S=140.346 + 13.572I	7.880
	M	0.529*	0.279	S=124.796 + 19.180M	7.102
	R	0.530*	0.281	S=123.117 + 19.739R	7.096
	L	0.339*	0.115	S=144.956 + 12.479L	7.871

R: coefficient of regression; R<sup>2</sup>: Coefficient of determination; SEE: standard error of estimation; P-value< 0.05.  
 \*: Statistically significant at p ≤ 0.05  
 T: Thumb, I: Index, M: Middle, R: Ring and L: Little

## Discussion

Stature is considered one of the main features for the identification of an unknown person and is usually assessed through the measurements of the limb bones. However, stature relies upon various variables like gender, genetic make-up, racial and geographical origin, social stratum, and physical activity [16]. The stature of a person is an inherent feature and it is one of the main parameters for individual identification. There is an established relationship between height and dimensions of various body landmarks, that helps forensic experts to assess stature from various body landmarks, and consequently, for forensic identification of persons [17].

One of the main purposes of a medicolegal investigation is to determine the character of an individual, particularly in situations where traces such as fingerprints are recovered and brought for assessment. A literature review revealed that fingerprint anthropometry has provided valuable data to determine the height for the aim of identification. Fingerprints are precious physical evidence frequently accessible in scenes of crime as robbery, homicide, rape, and firearm incidents [17]. Thus, the current study aimed to predict the stature of the person implicated or injured in a crime when hand impressions are present.

This study has been carried out among a sample of adult Egyptians for the identification of the stature from the length of the distal phalanges prints of both hands using regression analysis.

This study was concerned only with the length of distal phalanges print rather than whole finger length, as usually in the crime scenes, the print found to belong to the distal phalanges, since they are the part of the finger that deals with different objects.

The current research was conducted on 150 adult male and female individuals. The age of the participants ranged from 18 to 40 years, the average length of the adult's hand attained its final dimensions by the age of 16 years in males and 14 years in females [18].

Analysis of the study and comparison of stature done by researchers in other countries with our findings demonstrates a close relation of body height of Egyptian with Saudi Arabians and Chinese populations, while individuals from Slovakia and Australia were considerably taller. On the other hand, the shortest were the inhabitants of India and Bangladesh [16].

The research illustrated that the mean height of males is higher than that of females, demonstrating the presence of a statistically significant gender difference in the Egyptian population. This may be due to earlier skeletal maturation in girls than in boys; consequently, boys have two more years of physical growth [19].

Similar results were detected by other researchers in their studies [20].

Also, the mean distal phalanges print length measurements were found to be larger in males than females in both hands. Similar results were obtained by Krishan and Sharma, (2007) [19] where they found a statistically significant difference between the mean measurements of the hands of males and females.

Bilateral variation was statistically significant only for the hand

length of the little distal phalanges prints in the male group ( $p < 0.001$ ) and the hand length of the ring and little distal phalanges prints in the female group ( $p < 0.001$ ).

However, the study by Moorthy and Yin (2016) [14] on Malaysian Chinese showed that the size of left and right hands did not show any significant bilateral asymmetry in both genders.

The R values showed to be comparatively higher in males compared with females. This is consistent with the study by Jasuja (2004) [21] who studied the stature determination from hand and phalange length on Indian persons.

However, the study by Moorthy and Yin (2016) [14] on the Malaysian Chinese population showed that the R values were almost similar in both genders.

The coefficient of determination ( $R^2$ ), the predictive accuracy showed to be higher in males than females, and all measurements are found to correlate positively with stature determination, which is similar to the research done by Kornieieva and Elelemi (2016) [16], who studied the determination of stature from handprint measurements in a sample of the Saudi population.

Our research showed a statistically significant correlation of stature with distal phalanges lengths in both sexes, suggesting a linear and a nearby relationship between stature and these measurements, and illustrated that the length parameters are useful for stature determination, which coincides with many studies [22, 23].

## Conclusion

From this work, it was concluded that using regression equations, distal phalanges prints measurements can provide useful information for stature determination in the forensic field among adult Egyptians.

### Scientific Responsibility Statement

*The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.*

### Animal and human rights statement

*All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.*

### Funding: None

### Conflict of interest

*None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.*

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**How to cite this article:**

Wael Saad Kholeif. Stature estimation from the length of the distal phalanges prints among Egyptian using regression analysis. *Ann Clin Anal Med* 2021;12(8):895-899